

risk of conglutinations can be reduced by adjusting the operation and process parameters, such as tensile stress in the air gap, air gap height, filament density, viscosity, temperature and spinning velocity. However, when such conglutinations arise, the manufacturing process and fiber quality will be affected in a negative way because the conglutination may lead to breaks and thickened portions in the continuously molded bodies. In the most adverse case the manufacturing method must be interrupted and the spinning process must be started once again, which entails high costs.

Nowadays, a spinning process without conglutinations is demanded from the manufacturers of continuously molded bodies, for instance from the yarn manufacturers, as part of the textile processing chain, i.e. the individual filament stacks must not stick together because otherwise there will be irregularities e.g. in the yarn thickness.

A high profitability in the production of lyocell fibers, mainly staple fibers and filaments, however, can only be achieved when the spinneret orifices are arranged at a small distance from one another. A small distance, however, increases the risk of conglutinations in the air gap due to incidental contact of the continuously molded bodies.

For improving the mechanical and textile properties of lyocell fibers, it is of advantage when the air gap is as large as possible because in the case of a large air gap the stretching of the filaments is distributed over a greater running length and stresses arising in the continuously molded bodies that are just being extruded can be reduced more easily. However, the larger the air gap, the lower is the spinning stability or the greater is the risk that the manufacturing process must be interrupted because of the conglutinations of the spun filaments.

Starting from the principles of US 4,246,221, there are some solutions in the prior art in which the attempt is made to improve both the economic efficiency and the spinning stability in the production of continuously molded bodies from a spinning solution containing cellulose and tertiary amine oxide.

For instance, US 4,261,941 and US 4,416,698 describe a method in which the continuously molded bodies are brought into contact with a nonsolvent immediately after extrusion to reduce surface tackiness.

In WO 96/17118, conditioned air is used for cooling, the air having a water content of 0.1 g to 7 g of water vapor per kg of dry air and a relative humidity of less than 85%. The blowing rate was 0.8 m/s.

Finally, WO 01/68958 describes a blowing operation in a direction substantially transverse to the direction of passage of the continuously molded bodies through the air gap with a different goal. Blowing by means of an air flow is not meant for cooling the continuously molded bodies, but for calming the precipitation bath surface of the precipitation bath in the area where the continuously molded bodies immerse into the precipitation bath and the spinning funnel, respectively. According to the teachings of WO 01/68985, the length of the air gap can be increased considerably when the blowing process becomes effective at the immersion points of the capillary bundles into the precipitation bath so as to calm the movement of the spinning bath surface. It is assumed that the strong bath turbulence that is typical of spinning funnels is reduced by performing a calming blowing operation on the spinning bath surface in that a liquid transport through the spun filaments is induced by the blowing process on the precipitation bath surface. To this end just a weak air flow is provided according to the teaching imparted in WO 01/68958. It is essential in the teachings of WO 01/68958 that the blowing operation is performed shortly before the entry of the continuously molded bodies into the spinning bath surface. However, at the velocities of the air flow indicated in WO 01/68958 and at the location where the air flow is used for calming the spinning bath, no cooling effects can be achieved any more in the continuously molded bodies.

Thus, in the apparatus of WO 01/68958, in addition to the blowing operation described therein, which is performed shortly before the entry of the continuously molded bodies into the spinning bath surface, a cooling of the spun filaments near the extrusion orifices is also needed, as is known from the prior art. The additionally required cooling, however, results in a very expensive system.

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WO 00/06813 describes a method and an apparatus for the improved cooling of nonwoven filaments utilizing a turbulence inducing bar arrangement. The bar arrangement is disposed in a cooling gas stream between the blowing means and the filaments. The rate of the cooling gas stream is between 100 ft/min and 500 ft/min (about 0.5 m/s to 2.5 m/s). Without the bar arrangement the degree of turbulence of the cooling gas stream was very low at 1% to 3%.

In the light of the drawbacks of the solutions known from the prior art, it is the object of the present invention to provide an apparatus and a method which allow, at only a small constructional effort a combination of large air gap lengths and a high spinning density at a high spinning stability.

AMENDED SHEET

According to the invention this object is achieved for a spinning apparatus as indicated at the outset by a cooling gas stream that is turbulent at the exit from the blowing means.

So far it has probably been assumed in the prior art that cooling of lyocell type spun filaments can only be performed by way of a laminar cooling air flow because a laminar cooling gas stream produces a smaller surface friction on the continuously molded bodies than a turbulent flow and the continuously molded bodies are thus subjected to a reduced mechanical load.

Surprisingly, it has now been found that, in the case of a cooling gas stream exiting in a turbulent state and at a high velocities from the blowing device and having the same cooling capacity as a laminar cooling gas stream, considerably smaller amounts of blowing air seem to be needed than has been initially assumed. Due to the reduced amount of blowing gas, which is preferably achieved by virtue of small cross-sections of the gas stream, the surface friction on the continuously molded bodies can be kept small despite a turbulent blowing, so that the spinning process is not negatively affected.

The positive effect of the turbulent cooling gas stream is all the more astonishing as according to general fluid mechanics an improved cooling effect in the case of a turbulent flow would have had to be expected only at a small number of rows. To operate the spinning process in an economically efficient way at a high hole density, a multitude of rows must be provided so that according to fluid mechanics only a fraction of the continuously molded bodies should actually profit from the improved heat exchange conditions. Nevertheless, the use of a turbulent cooling gas stream yielded improved spinning characteristics also in the last rows most distant from the cooling gas stream.

Furthermore, one would have expected in the case of a blowing process performed with a turbulent cooling gas stream that due to the high velocities the spun filaments would be blown off and would thus stick together. Surprisingly, however, it has been found that the spun filaments are not impaired, but quite to the contrary the gas demand can be reduced.

The cooling area 19 is separated from the precipitation bath surface 11 by a second shielding area 21 in which there is also no cooling and/or no air movement.

The first shielding area 20 has the function that the extrusion conditions directly prevailing at the extrusion orifices are as little affected as possible by the subsequent cooling operation by means of the cooling gas stream in the cooling area 19. By contrast, the second shielding area 21 has the function to shield the precipitation bath surface 11 from the cooling gas stream and to keep it as calm as possible. One possibility of keeping the precipitation bath surface 11 calm consists in the feature that the air is kept as motionless as possible in the second shielding area 21.

The blowing means 14 for producing the cooling gas stream 15 comprises a multi-duct nozzle with one or several rows, as is e.g. offered by the company Lechler GmbH in Metzingen, Germany. In this multi-duct nozzle, the cooling gas stream 15 is formed by a multitude of circular individual streams having a diameter between 0.5 mm and 5 mm, preferably around 0.8 mm, which after a running path depending on their diameter and flow velocity are united to form a planar gas stream. The individual streams exit at a rate of at least 20 m/s, preferably at least 30 m/s. In particular, rates of more than 50 m/s are suited for producing turbulent cooling gas streams with a good spinning stability. The specific blowing force of a multi-duct nozzle of such a type should be at least 5 mN/mm, preferably at least 10 mN/mm. The Reynolds number is at least 2,500, and at least 3,500 at very high rates.

The thickness E of the curtain of continuously molded bodies 5, which is to be penetrated by the cooling gas stream, measured in a direction transverse to the direction of passage 7, is less than 40 mm in the embodiment of Fig. 1. Said thickness is substantially determined by a sufficient cooling effect being produced by the cooling gas stream in the cooling area 16 in the row 22 of the continuously molded bodies 5 that is the last one in gas flow direction 16. Depending on the temperature and velocity of the cooling gas stream and on the temperature and velocity of the extrusion process in the area of the extrusion orifices 4, thicknesses E of less than 30 mm or less than 25 mm are also possible.

extrusion orifices. In contrast to Comparative Example 4 a rectangular nozzle drilled all over its surface was used instead of a segmented rectangular nozzle.

The velocity of the cooling gas stream at the exit on the blowing means was about 12 m/s.

In Comparative Example 5 the air gap could be increased to about 20 mm and the spinning stability was improved considerably. As for the fiber data, however, no improvements were observed, especially since sticking occurred time and again.

In the following Comparative Examples 6 to 8, a cooling gas stream was produced by means of several multi-duct compressed-air nozzles arranged side by side in a row. The diameter of each compressed-air nozzle was about 0.8 mm. The exit velocity of the individual cooling gas streams from the blowing means was more than 50 m/s in Comparative Examples 6 to 8. The individual cooling streams were turbulent. The gas supply of the nozzle was carried out with compressed air of 1 bar overpressure; the gas stream was throttled by means of a valve for adapting the blowing velocity.

The spinning head comprised a rectangular nozzle of special steel that was drilled all over its surface. Otherwise, the spinning system of Comparative Examples 3 to 5 was used.

Comparative Example 6

Like in Comparative Example 5, the multi-duct compressed-air nozzle was mounted in Comparative Example 6 in such a way that the cooling area extended directly to the extrusion orifices, i.e., there was no first shielding area.

In this arrangement no improved results were observed; the spinning characteristics could not be rated as satisfactory.

Comparative Example 7

In this test the cooling gas stream was directed obliquely upwards in the direction of the nozzle and therefore had a component opposite to the direction of passage.

In Comparative Example 8 the spinning characteristics were not as good as in Comparative Example 7.

Comparative Example 8

In comparison with Comparative Example 7 the cooling gas stream had a flow direction obliquely downwards towards the spinning bath surface. Thus the cooling gas stream had a velocity component in the direction of passage.

In the arrangement according to Comparative Example 8 the best results could be achieved. The coefficient of variation of the continuously molded bodies was clearly below 10%. The spinning characteristics were highly satisfactory and left some room for finer titers or higher take-off rates.

It should here be noted that in Comparative Examples 6, 7 to 8 the cooling area and the precipitation bath surface had arranged thereinbetween a second shielding area in which the air was substantially stationary.

New patent claims 1 and 27

1. Apparatus (1) for producing continuously molded bodies (5) from a molding material, such as a spinning solution containing cellulose, water and tertiary amine oxide, comprising a multitude of extrusion orifices (4) through which during operation the molding material can be extruded into continuously molded bodies (5), a precipitation bath (9), an air gap (6) arranged between the extrusion orifices (4) and the precipitation bath (9), and a blowing means (14) for producing a cooling gas stream (15), the continuously molded bodies (5) being passed during operation in successive order through the air gap (6) and the precipitation bath (9), and the cooling gas stream (15) being directed in the area of the air gap (6) to the continuously molded bodies (5), **characterized in** that the cooling gas stream (15) is turbulent at the exit from the blowing means (14).

27. A method for producing continuously molded bodies (5) from a molding material, such as a spinning solution containing water, cellulose and tertiary amine oxide, the molding material being first extruded to obtain continuously molded bodies, the continuously molded bodies being then passed through an air gap (6) and stretched in said air gap and exposed to a cooling gas stream (15) from a blowing means (14), and the continuously molded bodies being then guided through a precipitation bath (9), **characterized in** that the cooling gas stream (15) exits from the blowing means (14) in a turbulent flow state.